US Army Corps of Engineers
Water Resources Support Center

1988 Annual Report

The Hydrologic Engineering Center
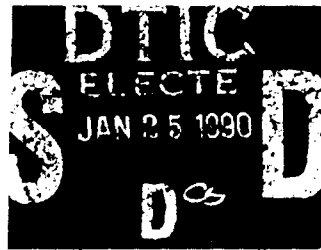
Planning

Research

Technical Assistance

Training

This annual report describes the accomplishments of the Hydrologic Engineering Center (HEC) during FY 1988 and presents the planned program for FY 1989.

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Water Resources Support Center
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Director's Comments

These comments are being written just two days before my official retirement and just hours after a wonderful retirement dinner given to me by my staff. My employment at HEC has spanned a twenty-four year period and I have served as Director of HEC for over sixteen years. As I look back over the years, I remember many eventful occasions. Some are humorous and many are special tasks that we performed. The most treasured memories, however, are of the many wonderful people that have been on the HEC staff and those that we have worked with.

We have been blessed over the years with a highly capable staff. The reputation of the staff for their technical competence is outstanding, and they have provided support to thousands of people and hundreds of organizations throughout the years. In our training function alone we have supported over 10,000 persons through the years. Programs developed by the staff are considered the state of the art by many organizations and countries. Our staff has truly established HEC and the U.S. Army Corps of Engineers as an organization that is a leader in the Water Resources Field.

While I feel much pride in this technical accomplishment, I feel even more pride in the attitude of the HEC staff. I routinely hear comments about the HEC staff from visitors and training course participants. They always tell me of the competence of the staff and how great they are at teaching, but more importantly they tell me about how friendly and helpful the staff is. The more comments we receive about our helpfulness, the more helpful we become.

The contribution of the two persons most responsible for the establishment of the HEC come to mind as I get ready to depart. Mr. Al Cochran (deceased), Chief of Hydraulics and Hydrology in OCE is remembered as the HEC founder. While he gave birth to HEC, the structure and character of HEC was developed in the first several years under the able direction of its Director, Mr. Leo R. Beard.

Several noteworthy projects come to mind when I think back of the many projects worked on by HEC staff. The projects mentioned here are noteworthy because of the great impact of these large projects on the other activities of the HEC. The first project is the work we did on the Tibbee River Navigation project in the early 1970's This project was one of the few projects where the HEC staff was involved in extensive use of the HEC-2 program. We used HEC-2 to determine storage data to establish routing criteria for HEC-1. We underestimated the work involved in the project and got behind schedule. To complete the study we had to get the whole HEC technical staff to do HEC-2 runs for several weeks.

The second project that comes to mind is the Susquehanna River Basin Study performed just after the Agnes Hurricane in 1972. This project had more effect on HEC activities than any other project in our twenty-five year history. In order to provide the manpower to evaluate the effects of the proposed flood control reservoirs and levee systems in the Susquannah basin, we took several unusual steps. We obtained two TDY people by requesting assistance from all Corps offices; we cancelled several training courses; and, we hosted two private contractors at HEC for many months.

The last major project I'll mention is the National Hydropower study. This project

*HEC ...
will develop
and teach
the technical
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new mis-
sions.*

was completed in the late 1970's after several years of work. This project was a massive undertaking for the Corps of Engineers. The task was to determine the maximum energy potential of all existing reservoirs in the United States. The work was done by the Corps district offices using computer software developed by HEC specifically for that purpose. IWR managed that study for the Corps. Three HEC divisions were actively involved in this major study.

The future of HEC and the Corps is somewhat uncertain. The Corps' traditional role of constructing large water resource projects is winding down and the Corps is exploring the possibility of new missions.

The Corps' solid reputation in engineering dictates that the Corps will be around for many years, and will be engaged in producing good engineering studies and projects. HEC will be following the Corps' lead and will develop and teach the technical capabilities needed to do whatever the Corps future missions dictate.

While the names and faces will change over the years, the pride, the technical competence and the friendly supportive attitude of the HEC staff will remain.

Bill S. Eichert
30 January 1989

FY 1988 Overview

*The Corps
has launched
a major
effort to
update all
Engineering
Division
technical
guidance.*

This past year has been a busy and eventful one for HEC. The Director for the past sixteen years was preparing to retire. HEC changed its long standing computer program distribution and support policy. HEC started research units to develop new, next generation fluvial hydraulics and watershed runoff computer modeling systems. We are committed to a five-year program of updating and modernizing the official hydrologic engineering technical guidance for the Corps. We made significant progress on research to develop communication materials for use with our cost sharing partners. HEC released new computer program products and supporting documentation in several technical application areas. The Center continues to be challenged to move ahead in our assigned hydrologic engineering and planning analysis missions with tight manpower and budget allotments. We have undertaken several management actions to meet this challenge.

Until this year, HEC computer programs could be obtained by the public from HEC for a distribution fee. Limited free support to non-Corps users was also available with a phone call. Now we only will provide this service to Federal agencies. HEC programs and technical user support are available from private vendors. A list of vendors is available from our office. We will continue to develop and maintain our software. Vendors and the user community will be informed of improvements and modifications through newsletters and other media. Also, the HEC software library is being transferred to the National Technical Information Service, the official government technical information distribution agency.

HEC directly assisted fifteen Corps offices during FY 1988. We also completed projects for the Federal Highway Administration and the Federal Emergency Management Agency. About thirty percent of our efforts this past year were devoted to reimbursable projects. Several major projects emphasized real-time water control.

HEC presented thirteen PROPECT courses involving seventeen weeks of training. We conducted four workshops totaling thirteen days. We also coordinated the following activities for Corps headquarters: Water Quality '88 Seminar, a Flood Damage Reduction Reconnaissance Phase Workshop, and the workshop on Calibration and Application of Hydrologic Models. Proceedings for all are available from HEC.

The Corps has launched a major effort to update all Engineering Division technical guidance. HEC is responsible for updating the hydrologic engineering guidance and will prepare the documents with the assistance of field office staff. We will develop nine new or replacement Engineering Manuals, fourteen new or replacement Engineer Regulations, and nine Engineering Pamphlets over the next five years. HEC drafted an ER entitled "Hydrologic Engineering Management" that is in final processing. We made substantial progress on a new River Hydraulics Engineering Manual.

New computer programs releases include: the PC (personal computer) based Flood Damage Analysis Package and the Preliminary Analysis System for Water Surface Profiles (PAS) PC program. Update releases include new HEC-1, HEC-2, and HEC-6 packages, and a PC

version of HEC-5 and supporting utilities. HEC published supporting documentation for these program releases and also released revised water control software documentation. A new computer program for interior flooding hydrology analysis is under development. It is designed specifically for the PC workstation environment. The target release is mid-1990. Program development activities are employing modern software development techniques.

HEC published several documents addressing drought, conjunctive use, and surface-groundwater interaction. As the drought continues, increased efforts are being devoted to this topic. A new research program entitled "Water Source Interrelationships and Impacts on Corps Projects", emphasizing surface-groundwater interaction, will begin in FY 1989.

The planned program for FY 1989 includes activities similar to FY 1988 with increased emphasis on technical guidance, communications materials for cost shared studies and a decrease in training activities. Technical assistance will continue to be substantial. See the figure below for the distribution of our work efforts. Emphasis will continue on advancing the technical capabilities of our computer programs with special attention paid to creating well designed interactive user interfaces for application in the PC workstation environment.

R&D
Reimbursable Assistance
Computer Program Support
Training
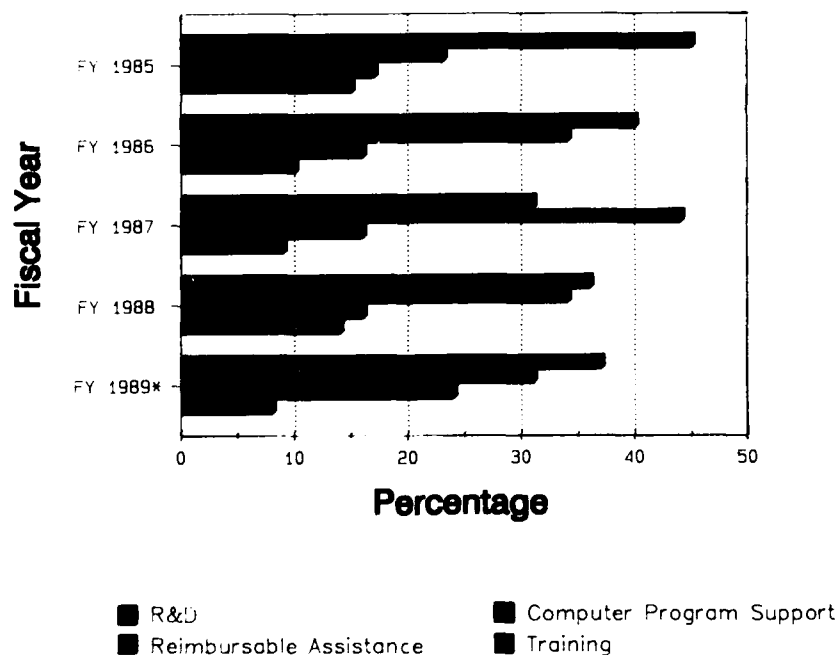
*Estimated

Goals of the Hydrologic Engineering Center

The primary goal of the Hydrologic Engineering Center (HEC), is to support the nation in its water resources management responsibilities by increasing the Corps technical capability in hydrologic engineering and water resources planning and management. An additional goal is to provide leadership in improving the state-of-the-art in hydrologic engineering and water resources planning.

By means of programs in research, training, planning analysis, and technical assistance, efforts are made to be aware of the problems and needs of the Corps and the nation. A commitment is also made to keep abreast of the latest developments throughout the profession, and to make use of this information in a manner best suited to the needs of the Corps.

HEC increases the effectiveness of the Corps and the profession by bridging the gap between the academic community and practicing hydrologic engineers and planning professionals. Research or training activities that can be best accomplished by universities are not undertaken. HEC incorporates state-of-the-art procedures and techniques into manuals and comprehensive computer programs. The procedures are made available to the Corps, United States and international professionals through an effective technology transfer system of technical assistance, publications, video tapes, and training courses.

Research supplements relevant research at universities, private industry and other agencies. It develops systematic procedures that produce a quality product and also save time for experienced specialists and enable less-experienced personnel to use procedures effectively.

Training efforts develop the U.S. Army Corps of Engineers work force and reduce the time necessary for young engineers and planning professionals to become proficient in hydrologic analysis. In addition, it also familiarizes more-experienced professionals with new developments.

Technical assistance provides advice and assistance to Corps field personnel in the application of new or unfamiliar procedures to solve unusual water resources problems and to more effectively utilize USACE resources.

Planning analysis develops and enhances analytical techniques and procedures to be applied in the water resources planning activities in Corps field offices.
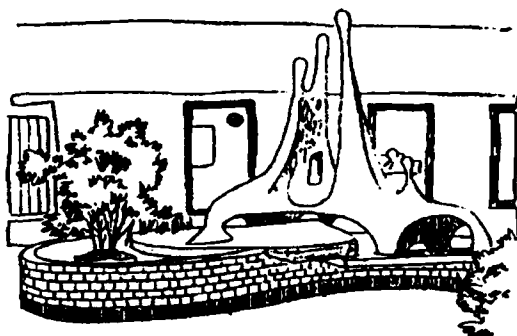
Administration/Funds

Administrative Services

Personnel, finance and accounting, contract, supply, and reproduction services are supplied to HEC by the Sacramento District.

Responsibilities

The HEC was established in 1964 to provide applied research, training, and technical assistance in hydrologic engineering to Corps field office. In 1971, HEC's responsibilities were expanded to include analytical planning so that activities of the HEC now involve a wide range of hydrologic engineering and analytical planning concerns.

The annual program of HEC is based on: (1) program direction from the Headquarters USACE Civil Works Directorate (Planning Division), and the Engineering and Construction Directorate (Hydraulics and Hydrology Branch); (2) the Corps Research and Development Directorate's activities; (3) requests for assistance by Corps field offices; (4) cooperative work with other Corps research laboratories; and (5) cooperative work with other government and professional organizations. This program is reviewed at an annual conference held with personnel from the Headquarters U.S. Army Corps of Engineers (HQUSACE), the Corps R&D Directorate, the Water Resources Support Center, and interested Corps field offices.

The HEC is a division of the Water Resources Support Center located in Fort Belvoir, Virginia. The Water Resources Support Center coordinates Corps-wide water resources support services for the Directorate of Civil Works, HQUSACE. The HEC has been grated authority, within the approved program, to deal directly with field offices on technical matters.
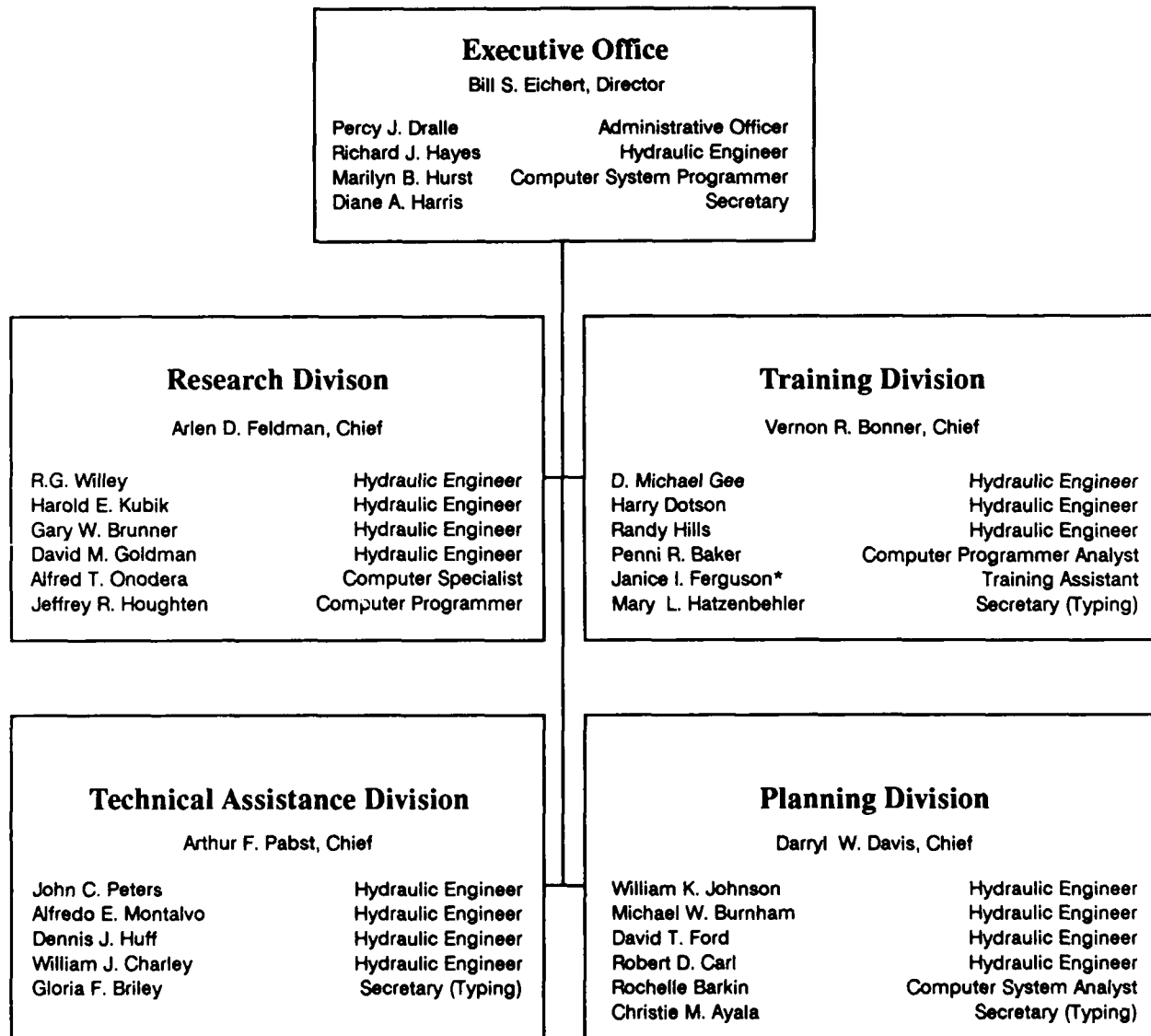
Facilities

The Hydrologic Engineering Center is located in Davis, California. Facilities include office space for the staff and visitors, a classroom with a capacity for thirty-six students, a library, a publications and video tapes storage center, and a computer facility. The computer hardware consists of a HARRIS 1000 computer, and a variety of supporting video, graphics and printing terminals. Forty-nine personal computers and twelve graphic terminals are also used.

Organization and Staff

The HEC is organized into five functional units as shown on the accompanying organization chart. HEC was authorized 36 full-time equivalent positions during FY 1988 and for FY 1989. Those persons employed on permanent status at the end of FY 1988 are shown on the organization chart. The HEC also employs temporary employees in professional, technician, and clerical capacities. Twenty-two students were also employed at HEC during FY 1988. An Intergovernmental Personnel Appointment position was occupied by a Utah State University faculty member who provided special hydrologic engineering technical expertise to the HEC.

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Organizational Chart

The Hydrologic Engineering Center

Executive Office

Bill S. Eichert, Director

Percy J. Dralle	Administrative Officer
Richard J. Hayes	Hydraulic Engineer
Marilyn B. Hurst	Computer System Programmer
Diane A. Harris	Secretary

Research Divison

Arlen D. Feldman, Chief

R.G. Willey	Hydraulic Engineer
Harold E. Kubik	Hydraulic Engineer
Gary W. Brunner	Hydraulic Engineer
David M. Goldman	Hydraulic Engineer
Alfred T. Onodera	Computer Specialist
Jeffrey R. Houghten	Computer Programmer

Training Division

Vernon R. Bonner, Chief

D. Michael Gee	Hydraulic Engineer
Harry Dotson	Hydraulic Engineer
Randy Hills	Hydraulic Engineer
Penni R. Baker	Computer Programmer Analyst
Janice I. Ferguson*	Training Assistant
Mary L. Hatzenbehler	Secretary (Typing)

Technical Assistance Division

Arthur F. Pabst, Chief

John C. Peters	Hydraulic Engineer
Alfredo E. Montalvo	Hydraulic Engineer
Dennis J. Huff	Hydraulic Engineer
William J. Charley	Hydraulic Engineer
Gloria F. Briley	Secretary (Typing)

Planning Division

Darryl W. Davis, Chief

William K. Johnson	Hydraulic Engineer
Michael W. Burnham	Hydraulic Engineer
David T. Ford	Hydraulic Engineer
Robert D. Carl	Hydraulic Engineer
Rochelle Barkin	Computer System Analyst
Christie M. Ayala	Secretary (Typing)

Summary - Positions Used

30 Full-Time Permanent
1 Part-Time Permanent

———

31 Total

*Part-Time Employee

Funding

HEC funding is provided by three main sources: the Civil Works R&D program, the Corps-sponsored training program, and reimbursable assistance provided to Corps offices and other agencies. Reimbursable assistance includes work for Corps District and Division offices; research and development laboratories; the Water Resources Support Center; the Planning Division, Civil Works Directorate, HQUSACE; Hydraulics and Hydrology Branch of the Engineering and Construction Directorate, HQUSACE; and other government agencies. Income and expenditure summaries for FY 1988 and projection for FY 1989 are shown in the following table.

Income and Expenses Summary, FY 1988
($1,000)

	FY 1988	Estimated FY 1989
Income		
R&D, Direct	$ 1,134	$ 1,190
R&D, Reimbursable	0	0
Training	442	241
Technical Assistance	901	700
Floodplain Management	70	50
Computer Program Support (GE funds)	185	785
Publications and Computer Program Income	191	0
Multi-Year Money from Previous FY	342 [1]	260
	$ 3,265	$ 3,226
Expenses		
Salaries and Benefits	$ 1,570	$ 1,615
Travel and Per Diem	77	80
Research Contracts	406	500
Professional Services	46	40
Computer Time and Equipment	209	200
ADP Maintenance	60	60
Reproduction	82	80
Services and Supplies	148	145
Space Rental	153	153
Administrative Services[2]	254	125
Subtotal	$ 3,005	$ 2,998
Multi-Year Money not Expended	260	228
Total	$ 3,265	$ 3,226

[1] Includes $9,000 R&D carryover
[2] Provided by Sacramento District

Research

Corps field office needs are the foundation of HEC's research program. New research needs are also identified by Corps headquarter offices, as well as other federal agencies. Most of HEC's research effort is technique-oriented and emphasizes a generalized solution to specific field problems. Research results are transferred to the field through HEC's training and technical assistance programs as well as through Corps' manuals, regulations, and HEC computer programs.

Planning, design, construction, operation and maintenance of today's multiple-purpose water projects require complex interdisciplinary analyses. These complex problems present major methodological and computational tasks to the water resources planner and engineer. The HEC seeks solutions to these problems through development of systematic methods and the use of the latest computational resources.

Research Program Accomplishments, FY 1988

Research activities were carried out in 16 work units. These work units represent specific technical areas that have been identified in the Corps R&D program. The HEC's primary research programs are entitled "Hydrologic Engineering" and "Cost-Shared Hydrologic Analysis." The HEC was also involved during FY 1988 in the Corps research programs for Remote Sensing and Risk Assessment.

Following is a discussion of the FY 1988 work units.

Research Work Units for FY 1988

Hydrologic Engineering Research Program (in priority order)

- River Analysis System
- Catchment Analysis System
- Analytical Methods for Water Resources Planning and Management
- Flood Forecasting Model for Use During Flood Emergencies
- Real-Time Reservoir Regulation
- Hydrologic Techniques for Leveed Interior Areas
- Water Resources Data Storage System
- Water Quality Procedures for Water Control Management
- Flood Warning Systems
- Analytical Techniques for Evaluating Reservoir Systems
- Modernization of Computer Programs

Cost-Shared Hydrologic Analysis Research Program (in priority order)

- Hydrologic Performance of Flood Damage Mitigation Projects
- Community Flood Threat: Definition and Communication
- Hydrologic/Hydraulic Analysis Design

Hydrologic Engineering Research Program

The **River Analysis System** work will produce a uniform set of tools, based upon existing models, for use by H&H engineers in a workstation environment. The tools will focus on the analysis of river hydraulics/mechanics to enhance and accelerate project design, and the prediction of project impacts and future operation, maintenance and repair costs. In FY 1988, improvements were made to HEC-2,

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primarily for hydraulic design, and the new program presented in Corps' training courses and workshops. Draft design of an integrated river analysis system was prepared and presented at several Corps' meetings; intermediate products were identified and development begun. HEC-6 was updated to include recent WES developments and was used in the Sediment Transport training course. The RMA-2, 2-D hydrodynamic model, was tested in floodplain applications and specific improvements identified and started.

The **Catchment Analysis System** work unit will develop methodologies and computer programs for simulation of complex river basin hydrologic processes. An integrated set of computer programs and methodologies for engineering workstations (computer, graphics devices, digitizers, high resolution CRTs, etc.) will be the central focus of the catchment analysis system. The analysis system will be built of modular components with a state-of-the-art catchment model as the central component. In FY 1988, new algorithms for the solution of kinematic wave land surface runoff and channel routing were incorporated in HEC-1. A new infiltration method (Green & Ampt) was also added. Several improvements were made in the mainframe HEC-1 and that program was implemented in its entirety on the microcomputer. A new PC version of the HEC-1 program, which includes DSS graphics and data storage/retrieval, was completed and is undergoing field testing. The requirements (desires) for the next generation catchment model were assessed and a preliminary design made.

The object of the **Analytical Methods for Water Resources Planning and Management** work is to adapt and improve existing methods and software, and create new analytical methods to better enable the Corps to efficiently perform its planning mission. The goal is to provide field offices with a family of computer programs and investigational procedures that will enhance the Corps capability to efficiently meet the requirements of the present and emerging policies governing water resources planning, primarily in the flood

A new PC version of the HEC-1 program, which includes DSS graphics and data storage/ retrieval, was completed and is undergoing field testing.

damage reduction area. FY 1988 accomplishments were: completed development and deployment of second phase microcomputer (PC) flood damage analysis package; completed EAD (affluence) and SID (pathname format enhancements); drafted example HEC program usage for formulation of flood control plans using branch-and-bound enumeration; hosted seminar on reconnaissance-phase flood damage reduction studies; acquired and implemented the EPPL PC-based GIS and ordered ARC/INFO; and, published several water supply/drought documents.

The **Flood Forecasting Models for Use During Flood Emergencies** work unit is directed toward developing a package of programs to use in forecasting the hydrologic response of a river basin. The forecasting techniques developed under this work unit were applied to additional basins for operational use by HEC and district office personnel. A basic continuous soil moisture accounting algorithm was developed for use in flood and low-flow forecasting. HEC's single event flood forecasting model (HEC-1F), with a new snowmelt function, was field tested on the Allegheny River Basin, Pittsburgh District. Coordination was initiated through DOD contract for COE access to NEXRAD precipitation data for flood forecast model use. Improvements were made to the user interface of the forecasting model-control (MODCON) program. Research results were transferred to COE field offices in a two-week training course.

The **Real-Time Reservoir Regulation** work unit emphasizes the development of reservoir regulation simulation programs and management information display for water control activities. A new option was added to HEC-5 and to MOD5 to allow the user to specify clock times when reservoir decisions will be made. The clock times can be specified differently for different days of the week and for different reservoirs. Extensive work was performed on the MOD5 program to link it to the MODCON program which controls all other HEC water control software. The MOD5 program was also linked to the HEC-DSS

routines and a draft user manual was prepared. The MOD5 program was also tested and used successfully in the Real-Time Water Control Training Course. New PC versions of HEC-5 and MOD5 were also created.

The **Hydrologic Techniques for Leveed Interior Areas** work units seeks to develop hydrologic analysis procedures for planning flood damage reduction measures for leveed interior areas. This work unit will develop procedures for efficient analysis of interior flooding by the basic methods of period-of-record, coincident probability, and single event. FY 1988 accomplishments were: completed preliminary requirements analysis and program specification definition for the new computer program in hydrologic analysis of interior areas; documented results in a detailed program specifications document used as the basis for procuring program coding; awarded program development contract; and, completed preliminary studies on analysis of interior and exterior time series data to characterize degree of dependence and coincidence.

The **Water Quality Procedures for Water Control Management** work unit seeks to develop, document and support computer models capable of evaluating downstream water quality impacts of releases from multipurpose, multi-reservoir systems. The new short-interval analysis version of HEC-5Q has been applied to the diurnal hydropower study on the Columbia/Snake River system. Several new utility-type computer programs were required to assist in preparing the input data for HEC-5Q. These programs included pre-processors for geometric, hydrologic and meteorologic data. A technical paper was prepared and presented in cooperation with NPD staff. The paper describes the numerous difficulties of working with real project data.

The **Flood Warning Systems** work unit will define needed hardware and develop software packages for use by the Corps in its flood warning projects. These systems will be designed for interlinkage with Corps real-time water control flood forecast/warning systems. FY 1988 accomplishments were: conducted a workshop on Flood Warning and Preparedness System (FWPS) for Corps offices; coordinated with Corps field offices on pilot installations of FWPS; and, attended regional meeting of FWPS users group to maintain awareness capabilities of existing FWPS equipment.

The **Analytical Techniques for Evaluating Reservoir Systems** work unit develops improved techniques for formulating and evaluating multipurpose and multireservoir systems. This unit addresses the planning, design and regulation aspects of reservoir systems. Regulation aspects refer to the scheduling of releases from proposed projects, not real-time regulation of existing systems. MENU5 which conveniently executes the HEC-5 family of programs, including DSS and DSPLAY on the PC, was developed and distributed. The rule curve capabilities of HEC-5 were enhanced to allow different criteria. Also, a new option to change the target channel capacities with rising and falling reservoir stages was added. A comprehensive set of test data were prepared to illustrate and test the HEC-5 program for all hydropower options. The HEC-5 system power routines were extensively modified to allow use in power systems where large non-power projects exist between tandem projects in the power system.

The **Water Resources Data Storage System** work unit has developed a data storage and retrieval system that allows hydrologic engineering/planning simulation models to communicate with one another. Such a data system eliminates redundant capabilities (such as graphics and statistics) in the individual programs, and makes the software more modular and easier to support. In this last year of the Data Storage System work unit, DSS user documentation was updated and distributed to field offices. New versions of DSS software were also delivered to Corps Harris computers and tested on MS-DOS PC systems.

... developed a data storage and retrieval system that allows hydrologic engineering/ planning simulation models to communicate with one another.

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The **Modernization of Computer Programs** work unit seeks to reduce software maintenance costs, improve reliability of production runs, and facilitate future improvements in HEC's hydrologic engineering and analytical planning computer programs. Conversion of HEC programs to FORTRAN77 (to enhance the portability of the programs and to make them usable on the PC) continued at a high rate. Workstation environment design for the general purpose editor (COED) and HELP command capabilities for input data records and variables for several HEC programs were completed. New routines were developed to allow FORTRAN programs to perform screen and data management functions on PCs. The design of an interactive input program was completed for HEC-1.

... investigate how remotely sensed data can be incorporated into a spatial data management system for hydrologic and environmental analyses.

Cost-Shared Hydrologic Analyses Research Program

The **Hydrologic Performance of Flood Damage Mitigation Projects** work unit addresses the problems of planning, design, and implementation of flood damage mitigation projects in which the technical studies and implementation cost are shared with a local sponsor. Technical and lay material is needed to enable the Corps and local sponsors to have a common understanding of the nature of flood damage mitigation measures and their respective strengths and weaknesses. The objective is to develop tutorial material that characterizes the hydrologic performance of flood damage mitigation projects. A draft tutorial was prepared. Public information materials are being collected under contract.

The **Community Flood Threat: Definition and Communication** work unit objective is to develop technical descriptive material that assists in communicating in an accurate technical, but lay context, the nature of flooding and the magnitude of flood threat to local project sponsors. The needs of Corps field offices were assessed and their existing documents for flood threat recognition reviewed. Similar documents from other agencies, states, and private industry were also included. From that information, new communication products will be identified and developed. A contract was let to review the flood threat and risk communication literature. A technical report and a draft brochure on "Explaining Flood Risk" were completed.

The **Hydrologic/Hydraulic Analysis Design** work unit seeks to define the relationship between technical issues and alternative analysis methods and scope of hydraulic and hydrologic studies for flood control investigations. Narrative material describing these relationships is being developed. This will provide guidance to field offices in formulating and supporting hydrologic engineering studies in cost sharing negotiations. In FY 1988, HEC made field office contacts, prepared several alternative annotated investigation plans, and initiated drafting of a test example.

HEC Work Units in Other Research Programs

The **Remote Sensing and Spatial Data Applications** work unit seeks to investigate how remotely sensed data can be incorporated into a spatial data management system for hydrologic and environmental analyses. The Earth Satellite Corporation contract to assess "Remote Sensing Technologies and Spatial Data Applications Relevant to HEC Programs and Mission" was completed. The results of the project were presented at the Corps 6th Remote Sensing Symposium. The project report covers: digital image processing; evaluation of PC-based image processing/GIS systems; role of remote sensing and information systems in specific hydrologic/ hydraulic tasks; and real-time estimates of precipitation and snow cover. In another contract, the "Procedural Manual for Interface of Imagery with SAM" was also completed. Continuous soil moisture accounting algorthims were implemented in HEC-1.

The **Risk Concepts in Flood Hydrology and Flood Damage Analysis** explores the concept of risk as it relates to flood hydrology and flood damage analysis. Its

goal is to develop analysis procedures and study documentation strategies to better communicate in practical, lay understandable style, the relationship between risk and flood control project formulation and evaluation. Numerical experiments and technical documentation that demonstrate risk aspects of flood hydrology, flood damage analysis, and project performance were completed. Issue papers were outlined and writing initiated.

Outlook for FY 1989

Research funding will remain at about the same level next FY. A new research program will begin entitled: Water Source Interrelationships and Impacts. Its objective is to document (through the experience of Corps offices) the interrelationship between surface and groundwater and the design and operation of Corps projects. A better understanding of these relationships can lead to better water management. Several work units will eventually be included in this research program, but only one was funded for FY 1989. The FY 1989 plans are described in the following paragraphs.

Hydrologic Engineering Research Program

River Analysis System. Culvert routines will be added to HEC-2 and a new users manual prepared. The restructured HEC-6 program will be released for PC's and a new users manual written to document the new capabilities developed over the last few years. A new version of RMA-2, suitable for floodplain analyses, will be obtained and tested. Integration of CADD systems with H&H studies will be investigated and documented via cooperation with the Sacramento District.

Catchment Analysis System. The general design of the new catchment analysis system will continue. The program capabilities summary completed last year will be carried forward into a general design

of the new system. This will include detailed definition and review of capabilities and the layout of the structure of the code. Existing HEC-1 efforts for interactive input, continuous simulation, and other new algorithms will be continued with cognizance of how they fit into the new catchment model system.

Analytical Methods for Water Resource Planning and Management. The several work tasks include: a) perform technical improvements in the computations, data entry, output display, and interactive features for components of the Flood Damage Analysis Package, b) implement the PC-based spatial data management systems ARC/INFO and EPPL and reissue Training Document No. 19, c) continue development and issue paper on branch-and-bound procedure for flood control system using HEC programs, and d) develop guidance and instructional material for level-of-detail and technical methods for two-phase planning.

Flood Forecasting Models for use During Flood Emergencies. Tasks include: field test the new continuous soil moisture algorithm in the HEC-1F Flood Forecasting model, develop feed-back adjustment optimization procedure to allow model to track observed basin response, test feed-back procedure in field applications, define interface to NEXRAD radar data, coordinate data exchange and analysis with the National Weather Service (NWS) Hydrologic Research Laboratory (HRL), and document algorithms and provide calibration guidance.

Real-Time Reservoir Regulation. Principal tasks include the development of the existing HEC-5 reservoir regulation model for efficient, economic, and practical real-time reservoir regulation with interface to a supporting data management system. The existing link between the reservoir regulation model and the real-time data collection and storage systems and the hydrologic flood forecasting models will be improved. Improved output displays will also be developed. The program MOD5

(interactively modifies input data to the reservoir regulation model) will be tested and enhanced to allow infrequent users to modify input data in a much more friendly environment.

Hydrologic Techniques for Leveed Interior Areas. Major tasks include: 1) determine criteria and guidance to assess dependence between coincident events; 2) assess need to upgrade technical procedures for the probability-based methods; and 3) complete detailed design, develop and initiate testing of new hydrologic analysis of interior areas computer program.

Water Quality Procedures for Water Quality Management. Existing computer models will be modified to better address the specific needs of water control staff. New documentation will be produced defining the new model concepts, input, output and limitations. The documentation will emphasize practical applications using the types of input data normally available to the field office staff.

Flood Warning System. Work efforts will continue to identify the emerging role of the Corps in evaluation, design, implementation and maintenance of flood warning-response systems (FWRS), provide training/guidance technology transfer to COE real-time water control data acquisition network, and evaluate existing software/hardware for FWRS.

Analytical Techniques for Evaluating Reservoir Systems. Tasks for developing and improving a generalized model for reservoir system simulation include improved computational efficiency in the simulation models, adaptation of model to workstation environment (including personal computers), improved input and output interfaces, improved rule curve options, and the addition of new program capabilities suggested by field offices. Case study documents will be developed to test and illustrate all flood control and hydropower options.

Cost-Shared Hydrologic Analysis Research Program

Hydrologic Performance of Flood Damage Mitigation Projects. The public information materials collected from various offices will be reviewed and the draft pamphlet will be revised, based on comments and the information gathered. A final document will be prepared for publication. The simple yet technically accurate tutorial will be in the form of a pamphlet with illustrations to maximize the interest and comprehension of local government officials and the lay public.

Community Flood Threat: Definition and Communication. Additional products (brochures/videos) will be formulated to provide accurate yet understandable communication of flood risk. The draft brochure on "Explaining Flood Risk" will be finalized and delivered to Corps field offices for use in communications with cost sharing partners. The brochures and videos provided by state and Federal offices will be reviewed for potential use Corps wide.

Hydrologic/Hydraulic Analysis Design. The research will identify and rank technical analysis areas important to hydraulics and hydrology studies in support of flood damage reduction investigations. Topics will include such technical subjects such as frequency analysis, river hydraulics, and stormwater runoff. A document will be drafted that describes hydrologic and hydraulic data needed, the associated studies, and supporting commentary. Products from this work will also support the on-going H&H guidance issuance initiative.

Water Source Interrelationships and Impact Research Program

The new work unit **Corps Activities in Ground Surface Water Management** will document the ground surface water interaction issues important to Corps

Work efforts will continue to identify the emerging role of the Corps in evaluation, design, implementation and maintenance of flood warning-response systems (FWRS), ...

planning and management concerns. Case examples will be identified, investigated and documented. The research plan for the Water Source Interrelationships and Impacts program, of which this is the initial work unit, will be fine-tuned.

HEC Work Units in Other Research Programs

> *Numerical experiments were performed that explore risk aspects of flood hydrology, flood damage analysis and project performance.*

Remote Sensing and Spatial Data Applications. The soil moisture component of the HEC-1 model will continue to be tested and developed in conjunction with the various data available from aircraft and satellite sensors. The Des Moines River demonstration project will be the primary test area for use of spatial soil moisture observations. Spatial variation in precipitation is also being evaluated in that demonstration project. GOES satellite-based precipitation measurements will be provided by the Army Atmospheric Science Lab. A methodology for estimating the spatial variation of precipitation using ground gages, radar and satellite data will be drafted.

Risk Concepts in Flood Hydrology and Flood Damage Analysis. Numerical experiments were performed that explore risk aspects of flood hydrology, flood damage analysis and project performance. The risk experiments results will be interpreted in two issue papers, one documenting the results and implications for an HQUSACE level of presentation, and another addressing and proposing methods/policy initiatives for sizing and reporting benefits of flood damage reduction projects in project investigation documents.

Planning

The goal of the Planning Division is to develop and implement analytical techniques for use by the Corps in water resources management investigations. Areas of emphasis include development of systematic methods for the formulation and evaluation of alternatives; development of computer programs capable of integrating objectives, performance, cost, benefits, and other important planning factors; development of strategies for using the variety of analytical methods in planning studies; and the integration of computerized information processing with planning. Significant efforts are devoted to consolidating research results into field-usable products that include computer programs, applications documentation, and information dissemination. Work efforts in FY 1988 were in several areas:

- Flood-Damage Reduction Planning
- Damage Computations and Data Management
- Spatial Data Management
- Water Supply Planning
- Miscellaneous/Other

Focus continues on the development of practical computer programs and companion user materials for use by field office professional staff. Areas that received particular emphasis this past year include flood-damage reduction planning, damage computations and data management, and water supply.

Flood-Damage Reduction Planning

Activities in this technical area are concerned with the strategies and technology for formulating flood-damage reduction plans, developing and managing planning data, and developing and providing information on significant policy issues.

Work has been steadily progressing on developing an analytical strategy for formulating solutions to flood damage reduction problems through application of the systems analysis technique referred to as 'branch and bound enumeration'. The attractiveness of the technique is that it makes use of existing detailed simulation models and thus does not require the usual simplifying assumptions of other systems analysis methods. Further testing is planned to be followed by a more complete general purpose implementation for HEC programs. Full implementation is awaiting a timely field office project so that testing may occur in the practical environment of the field office. Several possibilities have surfaced.

Flood warning - preparedness programs are an important emerging flood damage mitigation measure to be considered as either an integral component of a comprehensive flood damage reduction plan or as an interim measure until more complete measures are to be implemented. A seminar and training workshop were formulated and presented in FY 1987. Support from management levels in the Corps has resulted in increased attention to these measures. The seminar proceedings have enjoyed widespread distribution. The workshop was successful resulting in adding the course to the Corps PROSPECT system for presentation in FY 1989. During FY 1988 guidelines were prepared for investigation of flood warning - preparedness plans. The guidelines were prepared

for studies that would be performed by Corps Flood Plain Management Services staff. The guidelines are in use by several Corps field offices as a trial prior to more formal publication.

The planning process of the Corps is now a two-phased effort consisting of a 'reconnaissance' phase conducted by the Corps at federal expense followed by the feasibility phase, when appropriate. The feasibility study is cost shared with the local sponsor. Many questions have arisen regarding study management, scheduling, level of technical detail, and coordination for the reconnaissance phase. HEC formulated and hosted a 3-day seminar devoted to this subject. Invited participants from HQUSACE, Corps district and division offices, HEC, and a local sponsor organization made presentations and discussed the issues. An increased understanding of the special needs of reconnaissance studies emerged. Seminar proceedings were published and are available upon request.

The concepts of risk and uncertainty are not well understood by the public and by many professionals in the Corps. Work by HEC in this area has consisted of developing tutorial materials for internal and public distribution, and investigation of the variability in flood risk and associated flood damage and project benefits. An Engineer Pamphlet entitled Hydrologic Risk was published. A technical memorandum documenting experiments in flood damage estimates was prepared. This compliments a similar technical memorandum prepared in FY 1987 on flood hydrology and flood damage variability experiments. The next phase of the work will consolidate the experiments results into a management level discussion of the findings. In addition an issue paper will be prepared discussing approaches the Corps might consider in incorporating such information within the planning and decision process.

The HEC FY 1986 Annual Report documented completion and publication of EM 1110-2-1413, Hydrologic Analysis of Interior Areas. A need for a computer program to assist in the hydrologic analysis of these

The planning process of the Corps is now a two-phased effort consisting of a reconnaissance' phase conducted by the Corps at federal expense followed by the feasibility phase, when appropriate.

areas became apparent during the preparation of the manual. A requirements analysis document for the Interior Flooding Hydrology program was prepared and a contract awarded to complete program development. The contract calls for delivery of the program and documentation at the end of FY 1989.

Damage Computations and Data Management

The HEC has completed packaging into an integrated whole, programs needed for flood damage computations and associated data management. Mainframe and microcomputer versions are now available. Supporting user's instructions and applications guides are also available. The package is presented in many HEC training courses and now a 1-week PROSPECT course is devoted to its application in Corps studies.

The package is available on Corps Harris computers and diskettes may be obtained from HEC that enable installation on MS-DOS compatible microcomputers. The package is comprised of the computer programs SID (Structure Inventory for Damage Analysis), SIDEDT (Editor for SID program, EAD (Expected Annual Flood Damage Computation), PIP (Paired Function Input Program for Flood Damage Data), FDA2PO (for integrating HEC-2 profile output with the package programs), and the HEC-DSS (Hydrologic Engineering Center Data Storage System). The programs are automatically linked through the HEC-DSS thus enabling highly efficient processing of data from original field inventories through integration of hydrologic and hydraulic data in to the damage computation process.

The microcomputer implementation of the package operates via a menu driven shell that insulates the user from the usual machine and file manipulations typical of batch program implementation. The HEC-DSS linkage is functional for the flood damage programs EAD, SID, SIDEDT, PIP, FDA2PO, basic data management and

display features of HEC-DSS, with editing and help (on-line program user input descriptions) features provided via use of COED (a Corps developed text editor).

A near real-time flood damage computation program implementing features of several HEC programs but on an district-wide event basis is near completion. The program is being developed for the St. Louis District based on a program developed in past years for the Little Rock District.

Spatial Data Management

The HEC has been engaged in activities in the spatial data management area for the past thirteen years. The HEC-SAM system evolved to provide computational capability in this area. There are ten programs that comprise the mainframe/minicomputer version of the HEC-SAM. A number of the data management and applications programs have been adapted to the microcomputer environment. The data management/display programs are functional but outdated. They continue in modest use within the Corps. The need for a fully integrated Corps developed and maintained geographic information system (GIS) is questionable. Very capable commercial mainframe computer capability is generally available, as are microcomputer workstation based systems.

HEC is working toward a microcomputer based GIS capability. A lightweight, portable, microcomputer compatible digitizing tablet has been acquired and successfully used in several HEC projects. Companion microcomputer GIS have been acquired and are undergoing testing. The goals are to establish an in-house conventional PC based GIS workstation and develop applications instructions and documentation for the system to provide information and assistance to Corps field offices planning to perform GIS work. Should the system prove to be sufficiently attractive, HEC would assist in arranging

HEC is working toward a micro-computer based GIS capability.

for necessary acquisition/licensing. At present, this approach appears to be a desirable replacement strategy for the data management/display features of the HEC-SAM system. HEC-SAM could thus be retired. The applications programs, on the other hand, are as useful now as before - maybe more so with the increased availability of PCs. They will be modernized as appropriate.

Water Supply

The HEC is committed to developing study methods and analytical procedures to aid in water supply investigations. Work in this area continues to grow despite water supply being considered an incidental interest of the Corps. Work has been accomplished in several important areas: completion of a document on elements of conjunctive use water supply; completion of several policy-support studies; and training and workshops.

HEC completed a comprehensive investigation of elements of conjunctive use water supply. Several organizations prepared technical material for the project under contract to HEC. The material was subsequently consolidated into a final report. The document was made available to training course participants and can be obtained by request from HEC.

Several studies were undertaken to support HQUSACE policy needs. The studies were performed under the IWR Policy Studies Program. One study investigated and documented lessons learned from activities undertaken by the Corps in the Southeast during the recent (1985-86) drought. The findings have proven to be of timely value in the current nationwide drought. Another study documents opportunities for the Corps to reallocate existing reservoir project storage from present use to water supply needs. A third study looked into an analytical procedure for computing the reservoir cost to be allocated to water supply where the reservoir

may have lost utility since its construction from such factors a sedimentation. Documents have been published for these studies and may be obtained by request from HEC or IWR.

Training activity in this area was intensive. Two PROSPECT courses entitled "Groundwater Hydrology" and "Groundwater Quality" were presented. Final arrangements were also made for a drought workshop to held in late October 1988. A tutorial was also published that documents a case example of applying desk-top analysis methods (non-computer model analysis) appropriate for early stages of groundwater oriented studies. The case example is the Reelfoot Lake, Tennessee investigation.

A new research program entitled "Water Source Interrelationships and Impacts on Corps Projects" will be initiated in FY 1989. The research work will investigate the interaction between groundwater and surface water as it affects Corps water resources planning and management responsibilities.

Miscellaneous

Several years ago, the HEC developed a computer program to assist in planning for dredged-material disposal. The program is known as the Dredged-Material Disposal Management Model (D2M2). Given a potential array of disposal sites and dredged material sources and characteristics, the program selects an optimal ensemble of sites and efficient routing of dredged-material to the appropriate sites. Improvements have been made in the programs's computational algorithms. The program is now being enhanced to operate effectively in the microcomputer environment. Input, output, and display routines are being modified to function specifically for a PC workstation.

A research project completed in FY 1986 investigated the relationship between the accuracy of data acquisition for stream cross sections and the resultant accuracy of computed water surface profiles. The investigation developed a strategy to enable obtaining a desired water surface profile accuracy given stream characteristics and available mapping technologies for determining stream geometry. The findings of that investigation are implemented in the interactive microcomputer computer program PAS (Preliminary Analysis System for Water Surface Profiles). The program includes some additional utility features that make it useful for preliminary hydraulic studies. The program and supporting documentation are now available from HEC for application with MS DOS compatible microcomputers.

Training

The training activities of the Hydrologic Engineering Center (HEC) are designed to increase the technical capabilities of the Corps field offices to meet needs and solve problems in hydrologic engineering and water resource planning. The training effort is designed to assist field offices in their application of computer technology to the complex problems associated with water resource management. This technology transfer is carried out through a regularly scheduled set of training courses, special workshops designed to meet specific needs, state-of-the-art seminars, training assignments of individuals, and distribution of training course video tapes and a variety of technical publications. The emphasis is on practical applications such as utilizing appropriate technology to solve real-world problems.

Training Courses. About ten courses are conducted each year under the Proponent Sponsored Engineers Corps Training (PROSPECT) Program. Courses are one or two weeks in duration, and include formal lectures and practical problem-solving workshop sessions. Guest instructors from other Corps offices, universities and private industry are invited to participate. These instructors supplement the capabilities of the Center's staff.

Workshops. Special workshops are conducted each year at the request of individual District of Division offices. The requested workshop may be similar in content to one of the regular courses, or it may focus on a particular need for which training is not available elsewhere. The duration of these workshops range from one day to one week. They are usually held at the requestor's office to allow greater participation by the staff of the requesting Corps office, as well as local, state and other federal agencies.

Seminars. Seminars provide a forum for discussion of field problems and current solutions and for identification of needs for new techniques. The papers presented by participants are published as seminar proceedings.

Individual Training. A District or Division may request individualized training for one or more persons on prearranged topics. Also, training arrangements may provide for the individual to work under the direction of HEC personnel on a problem from the home office.

Video Tapes. Since 1974, HEC has made video tapes of selected training course lectures. The tapes are intended to supplement the training program by providing the course material to those unable to attend courses. These tapes are available to Corps offices on request. Copies are available to all others for the cost of duplicating and mailing the tapes.

Training Materials. Materials prepared and distributed as part of HEC's training program include training course manuals and training documents which illustrate procedures for solving technical problems or for applying computer programs.

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Training Program
Accomplishments, FY 1988

The HEC training program was larger than usual during FY 1988. Thirteen courses were conducted unter the PROSPECT system. Additionally, four workshops were presented and the biennial Water Quality Seminar was coordinated by the HEC. Courses and workshops conducted were:

Formal Courses
(17 weeks - 13 courses)

Flood Plain Hydrology (19-30 Oct 87)
Hydrologic Engineering for Planning (16-20 Nov 87)
Real-Time Water Control (30 Nov - 11 Dec 87)
Interior Flooding Hydrology (8-12 Feb 88)
Statistical Methods (7-18 Mar 88)
Flood Damage Analysis (11-15 Apr 88)
Hydrologic Engineering for Planning (25-29 Apr 88)
Advanced HEC-2 (9-13 May 88)
Hydrologic Data Management/DSS (23-27 May 88)
Planning for Hydrologic Engineers (6-10 Jun 88)
Sediment Transport (11-22 Jul 88)
Groundwater Hydrology (15-19 Aug 88)
Groundwater Quality (22-26 Aug 88)

Workshops
(2.6 weeks - 4 workshops)

HEC-2 Workshop, 3 days
Bismarck, ND

Flood Warning/Preparedness, 2 days
Washington, DC

Hydrologic Data Management, 3 days
Davis, CA

Flood Forecasting, 5 days
Fort Worth, TX

Training Program for FY 1989

A new course, **Flood Warning/Preparedness Programs**, was added to the schedule for FY 1989. The course will provide participants with an understanding of Flood Warning/Emergency Preparedness Programs and the technical requirements for planning, design, and implementation of these systems. The course emphasizes the roles and responsibilities of local, state, and federal agencies and includes presentation of several case examples. The role of the Corps continues to grow in this area. This course offers opportunities to professional staff in the floodplain management, hydraulics and hydrology, emergency operations, and civil works planning studies to become knowledgeable in this area.

HEC Training Schedule for FY 1989

Course Title	Weeks	Date
Hydrologic Engineering for Planning	1	14-18 Nov 88
Reservoir System Analysis	2	5-16 Dec 88
Flood Warning/Preparedness Program	1	23-27 Jan 89
Hydrologic Data Management	1	6-10 Feb 89
Flood Frequency Analysis	1	10-14 Apr 89
Flood Loss Reduction	2	8-19 May 89
Hydrologic Analysis of Floods	2	5-16 Jun 89

HEC Documentation

Computer program support is designed to provide user assistance and to produce and distribute documentation of newly developed and improved programs to aid users in the solution of hydrologic engineering problems. The HEC focuses a substantial portion of its resources on the development and documentation of "generalized" computer programs. Documentation includes user and programmer manuals for computer programs, training documents, technical papers, research and project reports, and seminar proceedings. During FY 1988 HEC distributed approximately 16,000 publications.

New and revised documentation issued during FY 1988 are listed. A catalog of HEC publications is available on request.

Computer Program Documentation

- Water Control Software, Forecast & Operations
- Water Control Software, Implementation & Management
- Water Control Software, Data Acquisition
- Flood Damage Analysis Package
- HEC-5 Users Manual Exhibit 8

Technical Papers

No. 118 Real-Time Snow Simulation Model for the Monongahela River Basin

No. 119 Multi-Purpose, Multi-Reservoir Simulation on a PC

No. 120 Technology Transfer of the Corps' Hydrologic Models

No. 121 Development, Calibration and Application of Runoff Forecasting Models for the Allegheny River Basin

No. 122 The Estimation of Rainfall for Flood Forecasting Using Radar and Rain Gauge Data

Research Documents

No. 27 Elements of Conjunctive Use Water Supply

No. 28 Desktop Techniques for Analyzing Surface-Ground Water Interactions

No. 29 Remote Sensing Technologies and Spatial Data Applications

IWR Policy Study 88-PS-1: Lessons Learned from the 1986 Drought

Seminar Proceedings

No. 18 Water Quality '88

Training Documents

No. 5 Floodway Determination Using Computer Program HEC-2

No. 24 Quality Modeling Reservoir System Using HEC-5

No. 26 Computing Water Surface Profiles with HEC-2 on a Personal Computer

Current HEC Computer Programs

Source code and test data for the HEC computer programs listed in the following table are available to Federal offices from HEC. These programs are written in FORTRAN and are provided on magnetic tape or floppy diskette. Most of these programs are operational on the HARRIS 500 and 1000 systems, and have been distributed to Corps offices. The programs are also available to Corps offices via access to the Control Data Cybernet (CDC) system. Many have been modified to FORTRAN77 standards and many are also available as microcomputer versions.

The Hydrologic Engineering Center (HEC) has provided software distribution and assistance to non-Federal parties for many years. Indeed, the provision of these services has grown markedly as more software products have come on-line and as the usage of HEC software has become more widespread. In order for the HEC to carry out its mission with available personnel and financial resources, **it is no longer possible to provide software distribution and assistance to non-Federal parties.** Additionally, counsel has stated that we should not provide distribution or support directly to the general public for HEC software which is available from and supported by the private sector.

To help meet the need for these services, the HEC has compiled a list of private vendors who have notified HEC of their capabilities to provide such services. A copy of the current list is available from HEC. We are also in the process of transferring our software to the National Technical Information Service (NTIS) for general distribution.

The HEC will continue to maintain its software and notify private vendors of software modifications. New software development will now receive additional emphasis. Information on modifications and new software may be obtained through the vendors or the HEC Newsletter.

Program Packages for the Personal Computer

The HEC has developed a package concept that provides more convenient application of batch processing programs on personal computers. A program menu provides for naming necessary program files, creating and editing input data with program COED, running application program(s), and reviewing output with program LIST. Once the files have been defined, the various programs can be executed directly from the menu. Additionally, COED can provide on screen display of program input requirements for each batch program, based on the input description from the program user's manual. Packages have been developed for HEC-1, HEC-2, HEC-5, HEC-6, and Flood Damage Analysis (FDA).

The FDA Package integrates the largest number of application programs to perform flood damage calculations. Programs included in the package are Structure Inventory for Damage Analysis (SID), the editor for SID (SIDEDT), Expected Annual Flood Damage Computations (EAD), Paired Function Input Program (PIP), a program to transfer HEC-2 output to the package programs (FDA2PO), and the Data Storage System (HEC-DSS) including graphical displays with DSPLAY, plus the COED editor and LIST for output review.

The following list of programs, by technical subject, indicates the distribution and micro version availability. Brief descriptions and computer hardware/software requirements for the programs are contained in HEC's Computer Program Catalog.

List of Computer Programs by Technical Subject

Program Name	Program Title	Micro Version Availability	Support Level
Data Storage System (DSS)			
DSPLAY	Display DSS	Yes[1]	1
DSSUTL	HEC DSS Utility Routines	Yes[1]	1
MATHPK	Mathematical & Statistical Analysis of Data Stored in a DSS File		1
REPGEN	Report Generator		1
DSSIN	Time Series Data to DSS	Yes[1]	1
DSSITS	Enter Irregular Time Series in DSS	Yes[1]	1
DSSPD	Enter Paired Data in DSS	Yes[1]	1
DSSSHF	Output DSS Data in SHEF Format		1
DSSTS	Enter Time Series in DSS	Yes[1]	1
SHFDSS	Load SHEF Data in DSS		1
WATDSS	Load WATSTORE Data in DSS	Yes[1]	1
CONVRT	Convert Data to Stage, Including Precipitation		2
EXTRCT	Extract Data From DSS File		2
GOESLD	Load GOES Data - DSS		2
NWSDSS	Load NWS Data Tapes in DSS		2
PIP	Paired Function Input Program - DSS	Yes	2
PREDWN	DWOPER DSS Preprocessor		2
DATMAN	Daily Time Series Data Management Program - DSS		3
MISFOR	LMVD Forecast Program - DSS		3
Groundwater Hydrology			
GWSP	Groundwater Simulation Package		2
GWMODL	Groundwater Model		2
GWPOST	Groundwater Model Post Processor (SOL)		2
GWPREP	Groundwater Model Pre-Processor		2
Planning Analysis			
FDA	Flood Damage Analysis Package	Yes	1
EAD	Expected Annual Flood Damage Computation	Yes	1
SID	Structure Inventory for Damage Analysis	Yes	1
D2M2	Dredged-Material Disposal Management Model	Yes[2]	1
DAMCAL	Damage Reach Stage-Damage Calculation	Yes[2]	1
HYCOST	Small-Scale Hydroelectric Power Cost Estimates	Yes	1
SIDEDT	Structure Inventory for Damage Analysis Edit	Yes	1
AGDAM	Agricultural Flood Damage Analysis		2
PINA	(PINA,SIPP) Interactive Nonstructural Analysis Package		2
PBA	Project Benefit Analysis (Including PPBA)		3

[1]Available to Corps only at this time
[2]HEC is not releasing to the public

Program Name	Program Title	Micro Version Availability	Support Level
Reservoirs			
HEC5	Simulation of Flood Control and Conservation Systems	Yes	1
HEC5Q	Simulation of Flood Control and Conservation Systems (Including Water Quality Analysis)	Yes	2
HEC3	Reservoir System Analysis for Conservation		2
RESYLD	Reservoir Yield	Yes[2]	3
HYDUR	Hydropower Analysis Using Streamflow Duration Procedures		2
CKHEC5	Input Data Checking Program for HEC5	Yes	2
INFIVE	Interactive Input Preparation Program for HEC5	Yes	2
RESTMP	Reservoir Temperature Stratification		2
DELTAS	Reservoir Delta Sedimentation		3
DEPOSS	Deposit of Suspended Sediment		3
INCARD	Flow Conversion for HEC5		3
RESACT	Reservoir Area-Capacity Table by Conic Method	Yes[2]	3
SWGRC	Spillway Gate Regulation Curve	Yes	3
SWRFR	Spillway Rating and Flood Routing		3
SWRPTG	Spillway Rating-Partial Tainter Gate Openings		3
River Hydraulics			
HEC2	Water Surface Profiles	Yes	1
HEC6	Scour and Deposition in Rivers and Reservoirs	Yes	1
PAS	Profile Accuracy System	Yes	1
DAMBRK	NWS Dam Break Model	Yes[2]	2
DWOPER	NWS Unsteady Flow	Yes[2]	2
CHANOP	Channel Structures Operation		2
EDIT2	HEC2 Data Editor	Yes	2
GEDA	Geometric Elements from Cross Section Coordinates	Yes	2
HGP	Hydraulics Graphics Package	Yes[1]	2
SHP	Stream Hydraulics Package	Yes	2
SUMPO	Interactive Summary Printout Using HEC2	Yes	2
CFLDRT	Comparative Analysis of Flood Routing Methods		3
CONTUR	Contour Plotting Program for RMA2	Yes[1]	3
DAMPRE	Pre-Processor for NWSDMBRK Program		3
PATH	Pathline Plotting Program for RMA2		3
RMA-1	Finite Element Network Generator	Yes[1]	3
RMA-2	2-D Finite Element Hydrodynamics (Horizontal)	Yes[1]	3
VECTOR	Vector Plotting Program for RMA2	Yes[1]	3

[1]Available to Corps only at this time
[2]HEC is not releasing to the public

| Program Name	Program Title	Micro Version Availability	Support Level
Spatial Data Management			
RIA	Resource Information and Analysis	Yes	1
DAMCAL	Damage Reach Stage-Damage Calculation	Yes[2]	1
AUTOMAPII	Line Printer Graphics for Polygon Data		1
BANK	Data Bank Manager	Yes	1
GRDPLT	Pen Plot of Grid Cell Data		1
GRIPS	Polygon to Grid Conversion		1
HYDPAR	Hydrologic Parameters	Yes	1
PLYPLT	Pen Plot of Polygon Data		1
REGIST	Data Registration Program		1
FOURV	Perspective Plot		2
Statistical Hydrology			
HECWRC	Flood Flow Frequency Analysis	Yes	1
HEC4	Monthly Streamflow Simulation		2
STATS	Statistical Analysis of Time Series Data	Yes	2
MLRP	Multiple Linear Regression Program	Yes	2
PDILFE	Partial Duration Independent Low Flow Events		3
REGFQ	Regional Frequency Computation		3
Surface Water Hydrology			
HEC1	Flood Hydrograph Package	Yes	1
HEC1F	Modified HEC1 for Real-Time Water Control Systems		1
HMR52	Probable Maximum Storm (Eastern U.S.)	Yes	1
HYDPAR	Hydrologic Parameters		1
PRECIP	Basin Precipitation Computations		1
SNOSIM	Snowmelt Simulation		1
INTDRA	Interior Drainage Flood Routing		2
STORM	Storage, Treatment, Overflow, Runoff Model		2
OPROUT	Stream Routing Optimization by Negative Local Flows		2
FORCST	Forecast River Flows by Regression		3
SFRO	Streamflow Routing Optimization Using Local Flow Pattern		3
UHCOMP	Interactive Unit Hydrograph and Hydrograph Computation	Yes	3

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Program Name	Program Title	Micro Version Availability	Support Level
Utilities			
COED	Corps Editor	Yes	1
HECLIB	HEC Subroutine Library	Yes	1
BB	Bulletin Board		1
REPLST	Report Lister		1
REPUTL	Report Utility Processor		1
FSIR	Fortran Source Inventory and Renumbering		3
Water Control			
MODCON	Interactive Executive for Model Control		1
APEX	Initiate Clock Schedule Tasks		1
ASYNC	Asynchronous Communication - Real Time		1
ASYNCI	Interactive Asynchronous Communication		1
DATAST	Data Status		1
IDXNWS	Index AFOS Products		1
LODNWS	Load AFOS Products		1
MONNWS	Monitor NWS Dedicated Line		1
PREFOR	Pre-Forecast Data Preparation		1
PREOP	Pre-Operations Data Preparation		1
VUENWS	View NWS Products		1
Water Quality			
HEC5Q	Simulation of Flood Control and Conservation Systems (Including Water Quality Analysis)	Yes	2
WQRRS	Water Quality for River-Reservoir Systems	Yes	2
HEATX	Heat Exchange Program	Yes	2
RESTMP	Reservoir Temperature Stratification		2
WQRRSQ	Stream Water Quality (WQRRSQ)	Yes	2
WQRRSR	Reservoir Water Quality (WQRRSR)	Yes	2
RWQM	Receiving Water Quality Model		3
THERMS	Thermal Simulation of Lakes		3
WEATHR	Weather		3
WQPLOT	Water Quality Plot (WQPLOT)		3
WQPROF	Water Quality Profile (WQPROF)		3
WQSTAT	Water Quality Statistics (WQSTAT)		3

[1]Available to Corps only at this time
[2]HEC is not releasing to the public
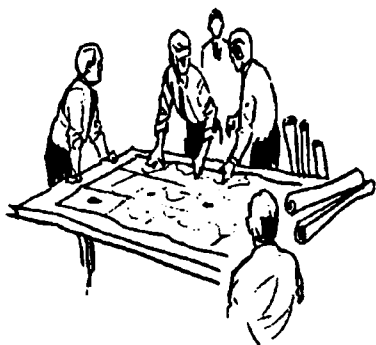
Technical Assistance

The primary objective of the technical assistance program is to provide assistance and guidance to requesting Corps field offices in the application of hydrologic engineering and planning techniques to solve water resource problems. Technical assistance activities are conducted on a cooperative and reimbursable basis. These activities enable HEC's technical staff to maintain close contact with Corps personnel in District and Division offices and to evaluate the effectiveness of new technology in a "project application" mode. This collaboration results in more complete and efficient solutions to complex problems, a continual improvement in methods, the testing and appraising of new approaches, and the recognition of needs for new research and training.

Each division of HEC helps Corps offices to apply models and to meet special needs with new developments, and acts in an advisory capacity in a number of technical subjects and A-E contracts depending on technical specialties and work load. Studies range in scope from brief reviews of work done by others to major studies requiring a team effort by several members of the HEC staff.

FY 1988 Accomplishments

In excess of $1,026,000 in technical assistance effort was expended in FY88 supporting 14 offices. The offices included 9 Corps Districts and Divisions, the Institute for Water Resources, the Waterways Experiment Station, Headquarters (Office, Chief of Engineers), the Federal Emergency Management Administration (FEMA), and the Federal Highway Administration (FHA). Major projects are listed in an accompanying table.

In the area of data management, assistance was furnished to the St. Louis District to enhance their DATMAN system used to manage daily Mississippi River related data.

An engineering guidance project for HQUSACE involved initial development of two Engineer Manuals and five Engineer Regulations.

River hydraulics projects constituted about 25% of all technical effort. Substantial HEC-2 program development has focused on adding features to support hydraulic design requirements. A procedure for simplified floodway determination was developed for FEMA, and a project for developing a PC-based interactive program for studying the cost of and predicting the accuracy of computed water surface profiles was completed for FHA.

Rainfall runoff analysis activities centered on the development and testing of new soil moisture accounting algorithms for computer program HEC1F. Substantial efforts were devoted to reservoir system modeling for the South Atlantic Division, and to analysis of the Prompton reservoir for the Philadelphia District.

Sediment investigations involved analysis of the Kaskaskia River for the St. Louis District and Cache Creek for the Sacramento District. Significant effort was devoted to development of Savannah River regulated frequency curves for the Savannah District.

Water control activities continue to comprise a significant portion of technical activities. Besides continued development of new software, applications assistance was provided in the development of models for the Allegheny River Basin (Pittsburgh District).

Water quality support to Corps field offices was funded through the Waterways Experiment Station under the Water Operations Technical Support (WOTS) program. A water quality seminar was conducted. Water supply studies funded by the Institute for Water Resources dealt with conjunctive use planning and with the 1986 drought.

HEC Project Reports
FY 1988

Number	Title	Date
88-1	Great Lakes Open Coast Flood Levels - Review of Frequency Analysis Procedures	Jan 88
88-2	Savannah River Flood Frequency at Augusta, Georgia	Dec 87
88-3	Hydrologic Analysis of Prompton Reservoir Modifications - Lackawaxen River Basin, Pennsylvania	Feb 88
88-4	Comparison of Modeling Techniques for Wetland Areas	Sep 88
88-5	Sedimentation Analysis in the Vicinity of the Kaskaskia River Navigation Project, Illinois	Sep 88

Technical Assistance Projects
FY 1988 - Expenditures*

Data Management ($14,000)
  LMS - Enhance DATMAN program

Engineering Guidance ($113,000)
  HQUSACE - Draft Guidance Documents

Economic/Planning Analysis ($88,000)
  HQUSACE - Monitor Reconnaissance Reports
  HQUSACE - Planning Assistance to States
  LMS - Project Performance Evaluation

River Hydraulics ($270,000)
  HQUSACE - Enhancements to HEC-2
  HQUSACE - Flood Plain Management
  NCR - FPMS Special Study
  FEMA - Floodway Procedure
  FHA - Profile Accuracy Analysis Software

Rainfall-Runoff Analysis ($50,000)
  HQUSACE - Enhancements to HEC-1

Reservoir System Analysis ($74,000)
  POD - Han River Analysis
  SAD - Reservoir System Analysis
  NAP - Prompton Reservoir Analysis

Sediment Analysis ($40,000)
  LMS - Kaskaski Study
  SPK - Cache Creek Study

Statistical Analysis ($44,000)
  SAS - Effects of Projects on Floods

Water Control ($214,000)
  HQUSACE - Software Support
  SPK - Water Control Data System Integration
  ORP - Allegheny River Basin
  SWF - Flood Forecasting Workshop

Water Quality ($63,000)
  HQUSACE - Water Quality Seminar
  WES - WOTS Field Support

Water Supply ($56,000)
  IWR - Conjunctive Use Planning
  IWR - 1986 Drought Study

* Only major projects shown ($10,000 or more)

Acknowledgements

HEC received excellent support and cooperation from many Corps offices. Colonel Richard A. Rothblum, Commander and Director, Water Resources Support Center, provided very helpful program and administrative guidance. Mr. Earl E. Eiker, Chief, Hydrology and Hydraulics Branch, Engineering Division of the Engineering and Construction Directorate and Mr. Jerry Petersen, Chief, Flood Plain Management and Coastal Resources Branch, Planning Division, Civil Works Directorate, and Mr. Jesse Pfieffer of the Directorate of Research and Development were particularly helpful in matters related to HEC's technical program.

Several Corps offices made significant contributions to HEC's training program. Greatly appreciated assistance was provided by the following offices:

HQUSACE
St. Paul District
Fort Worth District

Excellent support in the solution of hydrologic engineering and planning problems was obtained through technical assistance projects performed cooperatively with Division and District offices. These technical assistance projects were funded by field offices and provided the Hydrologic Engineering Center with valuable experience in developing and testing new technologies.

The active exchange of information and ideas with other federal agencies, universities, state and local governments, private industry, and professional societies is greatly appreciated by HEC. Through these contacts, HEC staff is able to keep abreast of current technological advances that may be applied to Corps programs.

One visiting scholar was especially helpful to HEC's program. Dr. Daniel H. Hoggan, Utah State University, made valuable contributions to the Center's hydraulic and hydrologic capability through his presence as an Intergovernmental Personnel Appointment.

HEC is especially appreciative of the support provided by temporary personnel. The temporary staff, listed below, provided a valuable extension to the Center's productivity in FY 1988.

James A. Alves-Foss	Computer Assistant
Rhonda C. Barrow	Clerk
Barbara A. Bauer	Civil Engineer
Kimberly A. Choate	Clerk Typist
Alaric I. Clinton	Computer Assistant
Brian J. Ebel	Civil Engineering Tech.
Chris S. Enright	Civil Engineer
Lynn A. Fornesero	Civil Engineering Tech.
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Keith B. Knight	Civil Engineering Tech.
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